GM'S RACE TO THE FUTURE

THE INSIDE STORY OF HOW THE WORLD'S BIGGEST AUTOMAKER CAME TO SEE THE HYDROGEN CAR AS ITS SALVATION—AND TOOK THE LEAD IN THE ENGINEERING CHALLENGE OF THE CENTURY.

BY RALPH KING

PHOTO-ILLUSTRATION BY PIER NICOLA D'AMICO

On a rotating stage bathed in blue light, the vehicle looked otherworldly, like something from far in the future. It was called the Autonomy, and vaguely resembled a giant skateboard. The only feature it shared with today's cars was its wheels. General Motors's unveiling of the vehicle at the Detroit auto show in January 2002 shook the car industry and made the *CBS Evening News,* with GM's boyish engineer Adrian Chernoff gleefully comparing the feat to that of the Wright brothers.

But not everyone was dazzled by the news. In a private meeting backstage with ExxonMobil shortly after the unveiling, GM executives reiterated that they believed so much in the Autonomy that they had pledged, publicly, to deliver a drivable version of the car by the end of the year. It was a $1 billion bet, and they were prepared to raise it by billions more in order to begin manufacturing within a decade. What they needed first, though, was some assurance that there would be a reliable supply of fuel—hydrogen—to fill up millions of the fuel-cell-propelled cars. Here, at last, the world's largest automaker said, was a vehicle so versatile, so green, so cheap to build, so *exciting* that it would crack the global market wide open. Would the world's largest energy company like a share of the spoils?

The Exxon reps exchanged glances. Then one cleared his throat. He called the Autonomy "a big surprise." But as for hydrogen, he said, "we really don't see a future in it." Petroleum was too plentiful. Exxon's new-fuels research was focused elsewhere. "Sorry, guys," he shrugged.

To the GM officials, the message was frustratingly clear: Exxon didn't believe that GM could, or even really wanted to, commit to hydrogen. Like GM's many critics, the oilmen knew the carmaker as a steadfast defender of the internal combustion status quo. GM had conspired to close down electric trolleys nationwide in the 1940s and allegedly had buried other promising technologies to keep the gasoline engine ascendant. The Autonomy, to the critics, was a head fake to forestall tougher gas mileage standards, or at best a flashy halfhearted hedge against global warming regulations. The concept would no doubt prove technically flawed, like GM's last billion-dollar belly flop, the battery-powered EV1, which

THE H-SQUAD From left: Team leader Christopher Borroni-Bird, mechanical engineer Mohsen Shabana, design architect Adrian Chernoff, and electrical engineer Robert Vitale became known as the "four horsemen" of GM's hydrogen car effort.

PIER NICOLA D'AMICO

THE CHAMPION R&D chief Larry Burns helped sell doubters within GM on the radical efficiencies of the hydrogen car's skateboard design.

the company touted in the mid-1990s as a planet-friendly car of the future before swiftly pulling the plug.

But Exxon (which declined comment for this story) and the legions of other skeptics may have misjudged GM. There is growing evidence that the Autonomy effort is, in fact, not a ploy. Inside GM the hydrogen car has come to be embraced as a way to leapfrog relentless rivals like Toyota, to regain a technological lead fumbled away decades ago, and to create an almost unimaginably vast new market. This car, GM's top executives now believe, will be so different that it could set in motion a complete turnover of the world's 700 million vehicles. It will be so simple that GM could make it for much less than the cost of today's cars—and sell it at a price affordable to at least some of the 88 percent of humanity that has never owned a car.

In addition to the $1 billion GM has already spent, it has committed an estimated several hundred million dollars a year—nearly a third of its research and development budget for preproduction cars—to hydrogen. More of its engineers and designers, about 500 in all, have been detailed to this long-term project than to any other in its history. The company has already quietly begun mapping out a plan to manufacture key components of the car. Insiders say GM may soon face ticklish discussions with its unions over the thousands of manufacturing jobs that its hydrogen car, which has relatively few moving parts, ultimately would kill off.

This is the story of how GM came to believe in hydrogen, and how a small band of mostly young hotshots, many from outside GM and some from outside the auto industry altogether, led the struggle to build a hydrogen car that doesn't just look good bathed in blue lights on a car show stage, but actually runs—and is closer to commercial reality than is widely believed. It involves a scramble to salvage technology that was oversold, brawls between top brass over timing and strategy, and a feverish race that has consumed engineers and designers in Detroit and across Europe.

The story is still unfolding: Huge technological hurdles remain. Toyota, also an increasing believer in hydrogen, is pouring resources into its own fuel-cell car and could overtake GM. Even within GM, factions that oppose the car are prepared to pounce if progress stalls. Other critics continue to expound on why the hydrogen future will never come to pass.

Adrian Chernoff takes a longer view. It is summed up by an Eleanor Roosevelt quote posted beside his desk: "The future belongs to those who believe in the beauty of their dreams."

It is March 2001 and Chernoff, once again, can't sleep. He reaches for the index cards beside his bed and dashes off a scheme for stacking and transporting skateboard chassis. Ideas ricochet around in his head during his shower and on his commute to GM's suburban Detroit campus. He enters Engineering North, passes an acre of partitions, and arrives at a cubicle where the "four horsemen" of the Autonomy team, as they're known inside GM, meet daily at a small table for a brain dump.

Chernoff's three teammates have logged years in Detroit. Team leader Christopher Borroni-Bird, who holds a Ph.D. in chemistry from Cambridge University, is a fuel-cell expert formerly with DaimlerChrysler. Mohsen Shabana, also a Chrysler refugee, is an Egyptian-born mechanical engineer. Robert Vitale, an electrical engineer whose grandfather worked for Henry Ford, is a

BILL PUGLIANO/GETTY IMAGES

THE SKEPTIC Vice chairman Bob Lutz once famously dismissed calls for fuel-cell autos by observing that humans and cows emit more greenhouse gases than cars. But the Hy-wire's economic potential has gradually converted Lutz into a strong backer of the project.

ROBERT GALBRAITH/REUTERS/LANDOV

26-year GM veteran. The sum of Chernoff's automotive experience is his restoration of the gold 1955 Chevy pickup parked in his garage and two summer internships at GM.

At the age of 28, Chernoff had just launched a consulting business in his hometown of Albuquerque, N.M., when Borroni-Bird, who'd heard about Chernoff's days as a hotshot intern, called with a job offer. GM had already sifted through its entire R&D portfolio, thousands of projects and blue-sky ideas, looking to fulfill a charge that CEO Rick Wagoner had made nearly three years earlier to R&D chief Larry Burns: "Find me big, bold innovations that will make this company a leader again." The fuel-cell engine was one of the few candidates Burns hadn't rejected. Borroni-Bird's pitch about using it and other technology to shape car design intrigued Chernoff. An engineer by training, Chernoff had designed rides for Walt Disney Co. and an escape module for NASA's space station, but he felt he had more to offer. In the previous five years, he had filled half a dozen journals with designs for more than 500 inventions.

IN ADDITION TO THE $1 BILLION ALREADY SPENT, GM HAS PUT AN ESTIMATED SEVERAL HUNDRED MILLION DOLLARS A YEAR AND 500 ENGINEERS INTO ITS HYDROGEN VEHICLE PROJECT.

By the time Chernoff joined GM as a design architect in December 2000, Borroni-Bird's team had examined lots of futuristic technology. A few months later, engineers from Swedish parts maker SKF Group stopped by with something the GM folks hadn't seen. It was an electronic system for steering, braking, and accelerating a car using a joystick shaped like a pilot's yoke, the automotive equivalent of a computer mouse. It required a lot of electrical power, much more than today's cars offer. Borroni-Bird saw an instant match with the 94-kilowatt output of GM's fuel-cell engine.

Within days the team had sketched what Chernoff called a "skateboard." It was an 11-inch-thick plank with an engine and computerized controls wedged inside. A single plug connected the plank to an empty body resting on top. It was a brilliantly simple configuration, and it triggered a series of 4 a.m. spasms in Chernoff's fertile brain.

"I'd go to bed empty and wake up driven, my mind going 10,000 miles a minute. How to make it, how to use it, how to finance it…," he says. He felt like a gold-rush prospector who, on his first day out, strikes a deep, rich vein. His journal ideas were mere "nuggets" by comparison, he says: "Here was a chance to build a story."

And the skateboard car needed a storyteller to get it rolling. It was so radical that few people could grasp it right off. Burns, the R&D chief, says it usually takes four repetitions for the far-reaching implications of its simple architecture to sink in: How the car's relative lack of moving parts lowers manufacturing and repair costs. How the ease of swapping bodies can turn a minivan by day into a sports car at night. How electronic controls speed driver reaction, and how "crush zones" protect passengers better than today's engine blocks. The story goes on and on.

By mid-April, Chernoff is applying the

final polish. He has vetted the story exhaustively with the other horsemen and in brainstorming sessions around GM. His stack of index cards now boils down to a few key props: a series of colorful cartoons highlighting the car's implications, descriptions of 45 possible patents, a nine-point poster for a management presentation, and a set of press releases. The only thing eluding him is a way to "reveal" the Autonomy to the outside world—a Hollywood moment.

"I got it," he whispers to a colleague one morning in the middle of a meeting. "I got the reveal." He bounds back to his cubicle to script the spectacle: Skateboard glides magically onto stage, spinning body drops from above, billowing blue smoke, blaring New Age music.

The following week Burns addresses GM's so-called automotive strategy board. It includes Wagoner and a dozen of the other most powerful executives in the company, and is the final arbiter of GM's high-risk bets on future projects. After three fruitless years, Burns believes his quest to meet Wagoner's command to find something that will transform GM has ended: The skateboard-based hydrogen car is the "springboard" GM needs. He launches into the story, and proposes unveiling the car at the Detroit auto show in January. Years ago, Burns woke up deaf, eventually recovering partial hearing with the help of cochlear implants. He still can't hear other voices above his own, so it's difficult to interrupt him.

But as he concludes, the questions fly. How do you know you can get it done in time? Are we promising something that might not be real? GM is in the midst of the biggest series of new model introductions in its history, to revive Chevrolet and other flagging brands. It has invested in a range of fuel-saving technologies, including gas-electric hybrids. Is now really the time for a dicey initiative that could potentially cost billions?

Burns presses the case. GM's potential reward for being first to tap that vast new market outweighs the risk of technical failure. The questions begin to dwindle, replaced increasingly by nodding heads. The group can see the possibilities, and soon they're agreeing with Burns that he must move fast: The concept is so logical, someone else will think of it soon. Burns is mildly shocked by what's happening. As soon as the group approves the car for a January debut, he muses to himself, "Is my hearing aid working?" Then it hits him. "Jeez, we've got less than nine months to deliver."

THE ITALIAN JOB The body for the Hy-wire "go" car took shape after a flurry of around-the-clock work—and several blown deadlines—at the Stile Bertone design studio in Turin, Italy.

At a kickoff meeting a month later, Borroni-Bird tells the team—two dozen GMers and contractors, plus the horsemen—that its first task is to build the "show" car, a nondrivable display model for the upcoming Detroit event. But the real challenge is the "go" car, which has to run reliably at 40 mph for a December 2002 demonstration. The car has two main components that have never been joined: its heart, a fuel-cell propulsion system developed by GM in Germany, and its brain, the by-wire controls from SKF of Sweden. To save time, the team will debug the components on separate chassis, then graft them together on a single skateboard, bolt on the body (to be handcrafted in Italy), and conduct safety tests. All in 18 months.

The timing is aggressive but doable, everyone agrees. The designers are already sketching. Once they're done, the Italians from the Stile Bertone studio can begin sculpting the body, around the clock if necessary. The Swedes' electronic "brain" will be road-ready in two or three months. Only the cautious Germans request more time for their motorized "heart" before signing on.

Burns doesn't buy the bravado. He figures there's a 10 percent chance of success, at best. "We had no design and a by-wire system that had never been driven," he recalls later. "I thought, 'Oh, man, we're in trouble here.'"

Work begins, but for Chernoff the next few months drag. The creative rush of crafting the Autonomy's story has faded, and his role is less defined. Anxious to stay at the center of the action, he volunteers for less glamorous scheduling and budget duties, and takes responsibility for design and construction of the go car's body. The designers are wary of him; some even cover up their work when he stops in to check their progress. And an uncomfortable distance has developed between him and his boss, Borroni-Bird.

"There were days when I wouldn't do a damn thing," Chernoff recalls. "Anything someone said would crush me in a second."

Finally, the Autonomy's Hollywood moment arrives, witnessed by 2,000 journalists. The team gets a salute from Burns, who calls it "the most exciting moment in my professional life." Chernoff does so many interviews that he loses his voice and is treated at a local hospital for exhaustion. When he returns to the office, Borroni-Bird tells him, "The team thinks you're grabbing all the glory. Don't do that again."

It's late February, and Chernoff has just arrived back at Stile Bertone in Turin, expecting more progress. A plaster model of the exterior stands half-finished on the shop floor. Only a crude mock-up of the interior is visible. The go car, now called the Hy-wire, has gone nowhere.

"I'm going to be an asshole today," Chernoff tells a colleague on his way to the workshop.

There he meets Roberto Piatti, the studio director, in his monogrammed shirt, and Anna Costamagna, his young new project manager. Chernoff hands them a list of uncompleted tasks and begins to recite. "Feb. 8: Exterior Plaster Complete. What's happening here?"

The answer isn't clear. "Feb. 15: Interior Design Completed. Why isn't this done?" He marches down the list. Where is this? Where is that?

Piatti offers excuses, but the truth is that the studio is racing to finish its own secret project—a new and improved version of a car called the Filo, which carried SKF's very first brain—for an upcoming auto show.

"We need you to do *our* work!" Chernoff barks. He hits Piatti and Costamagna with a long list of brutal new deadlines. Costamagna excuses herself, walks back toward her office, and bursts into tears. Within days, the studio fills with noise and dust, as workers in blue jumpsuits furiously trowel plaster onto a model in the morning and sculpt it in the afternoon.

At about the same time, GM engineers in the Netherlands are wrestling with a more frightening problem. Something's gone haywire in the Hy-wire's brain.

They had recognized it as soon as they drove the Filo demonstration car shortly after the kickoff. The steering didn't work. They couldn't keep the car going straight. SKF assured them that it could fix the problem quickly using "force feedback" software, which sends a tactile signal to the driver during turns. But in late 2001, vice chairman Bob Lutz, a former fighter pilot, test-drove a supposedly improved Filo and called it "scary."

Lutz's opinion mattered. The auto industry veteran had just joined GM and considered anything but internal combustion a pipe dream. Says Frank Colvin, recently retired head of GM's fuel-cell unit: "He'd challenge us constantly. He'd say things like 'You know how much greenhouse gas cows and humans are putting out? A whole lot more than cars. Gas en-

REVVING UP THE "SKATEBOARD"

A look under the hood of GM's revolutionary Hy-wire.

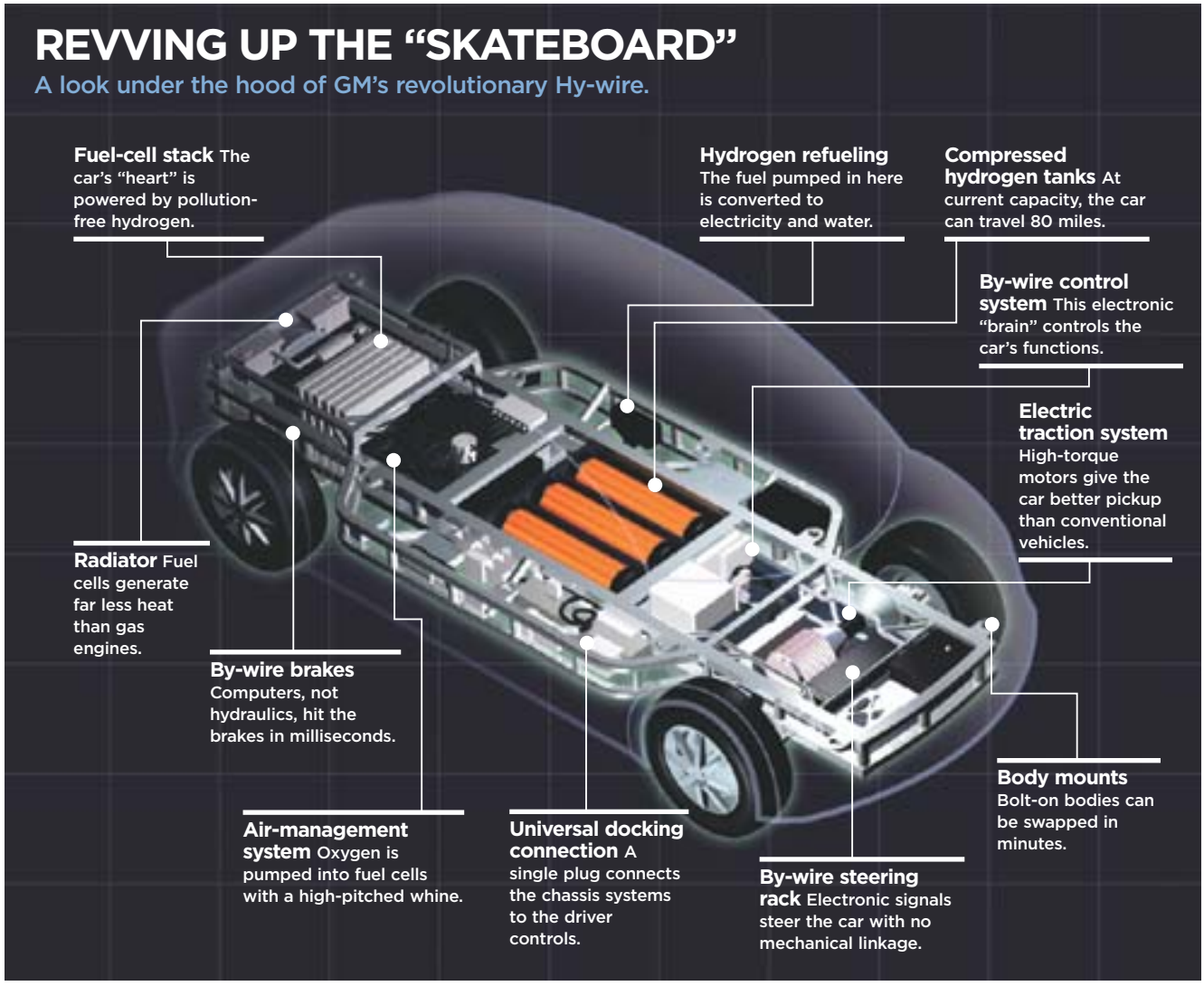

ILLUSTRATION BY STEPHEN ROUNTREE

GERMAN ENGINEERING Christof Scherl, second from right, oversaw the frantic work at a test track outside Frankfurt—and got the Hy-wire to run reliably just days before its public debut.

gines are going to be around for a while.'"

At lower ranks within the company, there were many other doubters, some of whom used Exxon's intransigence at the Detroit show to bolster their case, Colvin recalls. "They said, 'Hey, we've put in $1 billion, and we're going to spend a couple of billion more by the end of the decade. Are you sure?'"

By April 2002, skepticism seems warranted. The Hy-wire's brain is still misfiring. SKF resists loading it into the chassis hardware for a test drive, and that makes Mike Miller crazy. Miller, 29, a wiry redhead who had worked as an electrical systems engineer on the EV1, is camped out at SKF's research center in the Netherlands, staring for hours at the motionless chassis. SKF refuses to let Miller help code software, so he takes long jogs, sometimes chanting aloud, "I just want that vehicle to move."

Finally, in early May, Miller and the SKF crew roll the chassis out of the test bay. They turn on the battery. The brain activates, someone lets out a "Woo-hoo," and the contraption creeps forward. A few weeks later, GM dispatches a team to reevaluate the steering. It won't satisfy everyone, but at least it is no longer scary.

The Stile Bertone studio is stifling in the mid-June heat. Sweat trickles down Chernoff's back as he waits for Wayne Cherry, GM's long-reigning design chief, to begin his "walk-through," a mere formality after a design is "frozen." The body has materialized in a last-minute burst of Italian diligence. Cherry climbs in, grasps the yoke, and asks, "Did we design these seats to be uncomfortable?"

Cherry emerges and begins to circle the vehicle. He touches a spot where the rear window and side panel join and says, "This doesn't flow." He moves to the taillamps. "That looks unfinished." He surveys the roof. "This doesn't work." In minutes, he has identified 11 areas that need fixing.

"WE NEED YOU TO DO *OUR* WORK!" CHERNOFF BARKS AT THE ITALIANS, LAYING DOWN A LONG LIST OF BRUTAL NEW DEADLINES. THE PROJECT MANAGER RETREATS TO HER OFFICE AND BURSTS INTO TEARS.

Chernoff doesn't know what to say. Cherry's lieutenant, Ed Welburn, lays black tape on the car where changes are now due. It's too late to make any of them. The car still has months of testing ahead of it. A delay now will blow the year-end deadline, maybe unravel the whole project. Chernoff senses a year of work crumbling, his dream slipping away.

"I'm so depressed," he murmurs.

Cherry looks up, startled.

"I'm disappointed about all this," Chernoff tells him, his face flushed. The room falls away. Cherry is speaking to him now, taking him on another tour of the car, explaining in a fatherly tone how the taillamp glass is too pinched and how the roof needs more crown. The tutorial lasts half an hour.

When it ends, Chernoff bolts to his desk and dials Borroni-Bird in Detroit. "Chris, we've got a problem. It's huge," he says, explaining Cherry's logic and its likely effect: The car won't make the Paris Auto Show in September, the last big annual show of the year. It will have to wait until the Detroit show in January. Moreover, Cherry is now on his way to Le Mans, where he will spend the weekend with Lutz. Borroni-Bird immediately notifies Burns.

Burns is dead set against a delay. He fears that a competitor like Toyota might try to upstage GM at the next Detroit show with a skateboard car of its own. More important, he believes the project's momentum and GM's credibility ride on delivering a drivable car before year-end, as promised.

The following week, before the regular automotive strategy board meeting at GM headquarters, Burns confers with Lutz. Lutz feels that the body, particularly those pinched taillamps, still needs work. Burns is outwardly conciliatory, but thinks to himself, "Our success does not depend on what those lamps look like." In the meeting, CEO Wagoner hears both sides and throws down the gauntlet: "If we're going to show it in Paris, it has to be drivable by Paris."

That leaves the team just three months to publicly drive the Hy-wire, rather than six. The deadline worries Borroni-Bird; the body and brain are coming along, but the heart, the fuel-cell system, is troubled. Burns calls the head of the German fuel-cell team, Udo Winter. "To save this car, we've got to drive by Paris," Burns says. "Can you do that, Udo?" Winter says he can. But he doesn't sound so sure.

The accelerated deadline turns the next three months into a nightmare. Richard Hannis, a 52-year-old SKF engineer brought in to troubleshoot the still-buggy

HY-WIRE ACT The unveiling at the 2002 Paris Auto Show capped a 15-month ordeal.

brain, is sidelined by a heart attack. The Italians, after much banging and shouting, manage to fit the car's body onto the chassis. The Germans declare a corporate emergency, obtaining a special government permit to work overtime.

As September begins, Christof Scherl, the German engineer charged with taking the car over the finish line, and his team have entered what he calls the "red zone," the two-week period before demonstration day. Unshaven and sunburned from hours at GM's test track near Frankfurt, Scherl has seen SKF use up so much time debugging the electronic brain that the fine-tuning of the motorized heart has been delayed. After maddening weeks the heart and brain have begun to fire up together, but now, when the body is bolted on, the whole system dies.

Standing by the track one day, Scherl listens to SKF beg Borroni-Bird for one more steering software upgrade. "Why don't we forget about the fuel cell for now and use the battery chassis?" Scherl asks.

"That isn't the deal we made," Borroni-Bird replies.

As the SKF guy begins pushing the upgrade again, Scherl takes a deep drag on his cigarette and screams, "Because of your bullshit, we are still sitting here!" Ultimately, Borroni-Bird rejects SKF's plea.

Several days of mad tinkering and software tweaking follow. Then one evening the team rolls the car out to the track. It's 10 p.m. in Germany, 4 p.m. in Detroit, when Scherl speed-dials his cell phone. Borroni-Bird picks up and hears a high-pitched whine. Scherl is holding the phone in front of him as the car—heart pumping, brain whirring, body gleaming—slides past, the system's compressor whistling in its wake.

Scherl brings the phone back to his ear. "Did you hear that?" he asks.

"Yeah," Borroni-Bird says.

"It's going!" Scherl shouts. "It's going!"

Borroni-Bird asks, "Is it going fast?"

Actually, at that moment, the car is going 5 mph. But during the next few days, the team coaxes it up to the 40-mph target. The car cruises through demonstration day and wows Paris. "I have seen the future of motoring," raves a *Times of London* columnist. "It sounds like a hair dryer and leaves a trail of steam like a kettle on boil."

WHAT THE DOUBTERS DON'T GET, BURNS SAYS, IS THAT SIMPLE ECONOMICS HAVE FORCED GM TO BE SERIOUS ABOUT HYDROGEN: MAKING CARS TODAY IS A LOUSY BUSINESS, AND GM SEES THIS AS A POTENTIAL $1 TRILLION MARKET.

Building a drivable skateboard car from scratch in 15 months is a technological and design miracle. But in the marathon to create a commercially viable hydrogen car, GM has more miracles to achieve. In a cluster of unmarked blue-glass buildings in the western New York town of Honeoye Falls, GM engineers are trying to conjure the next one: a fuel-cell engine cheap and durable enough for mass production.

The work in Honeoye Falls is top secret; Burns won't talk much about it for competitive reasons, he says. But GM has made more progress on fuel cells than it has let on. The company last reported in 2001 that its fuel-cell "stacks" had generated 1.75 kilowatts per liter of power density, a key measure of performance. The figure is considerably above that today, though GM won't provide specifics. And GM's fuel-cell costs are below the $500 per kilowatt it cites and moving toward its $50 production target.

GM must reach that benchmark within about three years in order to begin the four-year process required to get plants built and cars rolling off assembly lines by the end of the decade. Thus, in 2006, Burns will likely go once more before the automotive strategy board for a final up or down on the car; if it's green-lighted, GM will commit to investing additional billions. GM declined to estimate expenditures, noting that no production decision has been made yet. But analysts say the cost of creating the car and starting full-scale production could easily exceed $5 billion.

Three years feels like tomorrow in the research labs of Honeoye Falls. There, a squad of electrochemists and engineers races to perfect the fuel cell. They spend hours peering into $250,000 microscopes at atoms dancing on the surface of fuel-cell membranes. The membranes, coated in platinum, react with hydrogen to create electricity. One goal is to wring out the greatest yield of electrical current using the smallest amount of $629-per-ounce platinum. "We're still not using every particle of platinum effectively," says Dave Wetter, the chief development engineer at the facility.

Inside a clean room in the development building next door, technicians in bunny suits clamp together fuel-cell stacks. Every

BRYAN MITCHELL/GETTY IMAGES

GENTLEMEN, START YOUR FUEL CELLS

Who's got pole position in the race to market a hydrogen car.

General Motors
Hy-wire

Hy-wire has established GM as the company to beat. Given the progress it is quietly making on fuel cells, its next skateboard car should have longer range, higher top speed, and better handling—and be cheaper to make.

Toyota
FCHV

Heavy research spending for more than a decade makes Toyota GM's toughest rival. It already has eight fuel-cell-powered vehicles with Highlander SUV bodies on the road. Toyota has also unveiled a skateboard-based show car, though it's not yet drivable.

Ford/DaimlerChrysler
Ford: Focus FCV;
Daimler: F-cell, Citaro bus

Together, Ford and DaimlerChrysler own 36 percent of Ballard, a pioneering fuel-cell maker. Daimler fields many fuel-cell prototypes and Ford will continue testing 15 cars during the next year. But the companies' efforts have been hurt by Ballard's problems, as well as their own.

Nissan
Xterra

Nissan has collaborated on fuel-cell technology with Ballard and United Technologies, and is now developing engines with Renault, which owns a 44 percent stake in the company.

Honda
FCX

The city of Los Angeles is testing three FCX vehicles equipped with Ballard fuel cells; the cars, based on the Honda Civic, use conventional chassis and technology from existing Honda vehicles.

quarter they test a new stack with the latest refinements. The team is now assembling engines that are dramatically smaller, simpler, and longer-lasting than the one that powered the Hy-wire.

Wetter pauses at a card table stacked with what look like sheets of black Saran Wrap and the other flimsy components of a fuel-cell engine. A few feet away on a long workbench are the hundreds of metal parts from a six-cylinder internal combustion engine. "A lot of our employees couldn't tell you where the spark plug goes, and couldn't care less about GM. They just want to make fuel cells real," Wetter says, waving the plastic wrap in the air. "The speed at which this technology is moving keeps them here. The naysayers have no idea how fast that really is."

Burns acknowledges that many people won't believe GM is committed to hydrogen until they see cars in the showroom. "How many of these skeptics have driven a fuel-cell car?" he asks testily, adding that one of the most prominent skeptics ever—Bob Lutz—has become "an enormous ally." What the doubters don't get, Burns notes, is that simple economics have forced GM to be serious about hydrogen. Making cars today is a lousy business. New models typically cost $1 billion in factory retooling and other expenses. Chronic overcapacity assures price wars. GM is faring better now than most automakers; it earned $1.7 billion last year on revenue of $187 billion—a whopping 0.9 percent profit margin.

As GM sees it, however, the potential market for hydrogen cars is epic—"more than a trillion dollars," Wagoner says. And because many different vehicles will fit on the same skateboard, GM says manufacturing costs could fall to a fraction of current levels. It's the lure of explosive profits that drives GM's hydrogen push, and the company doesn't want other carmakers to cash in first. "My golden rule," Burns says, "is do unto others before they do unto you."

Right now, the rival that GM must do the most unto is Toyota. Ford Motor and DaimlerChrysler are relying on Ballard Power Systems to develop fuel-cell engines, but it has been hampered by management turmoil, and Ford and Daimler seem to have soured on hydrogen lately, amid financial problems. Toyota introduced a skateboard car at the Detroit show last January, as Burns had suspected it would (the car isn't drivable yet). And though Toyota is better known for its ultraclean, fuel-efficient Prius gas-electric hybrid, it has worked on hydrogen cars since 1992. It won't say how much it has invested, but industry insiders say it's outspending GM right now. Moreover, Toyota has actually put hydrogen cars on the road, leasing eight fuel-cell-powered Highlander SUVs to trial customers. Drivers say they performed beautifully, but in May one car sprung a leak during fueling and Toyota briefly recalled them. Toyota, unlike GM, hasn't announced when it might begin marketing the cars.

The outcome of the hydrogen derby, of course, is impossible to predict. Bill Reinert, Toyota's U.S. manager of alternative-fuel vehicles, concedes that GM leads in fuel-cell stack technology. But he says Toyota's public road tests give it an edge, and its other engine parts—compressors and humidity controls—are more advanced. Scott Samuelsen, a hydrogen expert at the University of California at Irvine, was one of a few outsiders recently allowed to tour Toyota's fuel-cell complex. "The amount of investment shocked me," he says.

Many things could happen between now and 2010 to kill GM's hydrogen car—technical troubles, a management change, the failure to make any progress on a fueling infrastructure. To Adrian Chernoff, those matters don't merit much thought. "We've changed the world," he insists. Chernoff, now 32, has been at loose ends since the grueling march to build the Hy-wire. He has considered new jobs at GM, but most of them, in Chernoff's mind, pale in comparison with the crazy creative high of helping reinvent the automobile. Some friends think he may once again strike out on his own. GM might not always be the place where he pursues them, but Chernoff still believes in the beauty of his dreams. ✦

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